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39TH ANNUAL CONVENTION
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IN THIS ISSUE

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THE 39TH ANNUAL CONVENTION

The 39th Annual Convention of the Society of the Sigma Xi is scheduled for Wednesday, December 28, at 4.00 P.M. in in Richmond, Virginia, in conjunction with the meeting of the A. A. A. S.

The Executive Committee of the Society will meet at 12.00 of the same day in the Hotel Jefferson, which is the general headquarters for the meetings.

Chapters and clubs are entitled to send three delegates to the Convention. Chapters and clubs are urged to appoint as delegates individuals who will be sure to be present at the Convention, and to send the names of the delegates to the national secretary as soon as appointed. They are also urged to communicate to the national secretary before December 1st any items of business which they may like to have the Executive Committee or the Convention consider, in order that place on the program may be assigned for such consideration.

Among the important items of business to come to the Convention is the following amendment to the constitution:

> "That a Section 4 be added to Article II of the present constitution, reading:
>
> Article II, Section 4. The charter of an established chapter of Sigma Xi may be revoked only by a three-fourths vote of a convention following a recommendation of the Executive Committee, which recommendation has been communicated to each chapter not less than four weeks before the date of the convention."

The 17th annual Sigma Xi lecture under the joint auspices of the A. A. A. S. and the Society of the Sigma Xi will be given Wednesday evening at 8.30 by Dr. W. E. Durand on the topic, "Modern Trends in Air Transport."

REPORT OF COMMITTEE ON THE SIGMA XI LECTURE SERIES FOR 1939

Lecturer	*Topic*	*Available Dates*
Carl D. Anderson	"Cosmic Rays and New Elementary Particles of Matter"	March 12-26
Jerome C. Hunsaker	"Recent Advances in Aeronautics"	April 16-30
Alfred C. Lane	"Does Mother Earth Show Her Age?"	March 27-April 9
Howard P. Robertson	"The Expanding Universe"	January 22-February 5
Louis J. Stadler	"The Experimental Alteration of Heredity"	April 16-30

Carl David Anderson is Assistant Professor of Physics at the California Institute of Technology. He holds the gold medal from the American Institute and the Cresson medal from the Franklin Institute. He was awarded a Nobel prize in 1936. His researches have covered X-ray photoelectrons; cosmic and gamma rays; positive electrons; and induced radioactivity.

Jerome C. Hunsaker is Head of the Department of Mechanical Engineering at the Massachusetts Institute of Technology. He holds the Daniel Guggenheim medal, and has been a member of the National Advisory Committee on Aeronautics, the Federal Aviation Commission, the Army and Navy Technical Aircraft Board. He is a member of the National Academy. His field of work is aeronautical engineering.

Alfred C. Lane is Emeritus Professor of Geology at Tufts College. He is a member of the American Academy, which he has served both as councilor and librarian. His principal scientific work has been done in petrographical geology; the geological applications of the theory of heat; grain of igneous rocks; mine waters and connate waters; and geologic time.

Howard Percy Robertson is Associate Professor of Mathematical Physics at Princeton University. His field of work is relativity and the quantum theory.

Lewis J. Stadler is connected with the United States Department of Agriculture, and is located at the University of Missouri. He is the principal geneticist of the Bureau of Plant Industry of the Department, and was recently elected to the National Academy. His particular field of work is in plant breeding and mutation.

H. Jermain Creighton,
Harlow Shapley,
Harold C. Urey.

EDITORIAL NOTES

Arrangements for lectures by the Sigma Xi lecturers are to be made through the office of the National Secretary. The chapter or club engaging the lecturer is responsible for an honorarium of $50 for each lecture, which is to be sent to the National Secretary before, or at the time of, the lecture. The chapter or club is also responsible for the local entertainment of the lecturer. The National Society meets the traveling expenses of the lecturers.

Chapters and clubs are asked to indicate their choice of lecturers and dates not later than November 15, giving first, second and third choices. As soon after November 15 as possible, chapters and clubs will be informed regarding the itineraries of the lecturers.

At its April meeting the Executive Committee voted that the larger institutions should be given opportunity to contribute to the traveling expenses of the lecturers. If any of the chapters is in position to make such contribution, it may be sent to the National Secretary with the lecturer's honorarium. These contributions will, of course, make possible a larger series of lecturers or larger itineraries, which would mean a wider distribution of the lectures.

LECTURERS AND TOPICS FOR 1937

Edgar Allen, Yale University—"Internal Secretions in Reproduction"

L. O. Kunkel, Rockefeller Institute—"New Views in Virus Disease Research"

E. O. Lawrence, University of California—"Atoms, New and Old"

T. S. Painter, University of Texas—"Recent Developments in Our Knowledge of Chromosome Structure and Their Bearing on Genetics"

H. C. Urey, Columbia University—"The Application of Physical and Chemical Methods to the Problem of the Separation of Isotopes"

LECTURERS AND TOPICS FOR 1938

F. G. Benedict, Nutrition Laboratory, Boston—"Animal Metabolism—from Mouse to Elephant"

E. N. Harvey, Princeton University—"Electrical Potentials of the Human Brain"

K. E. Mason, Vanderbilt University—"Vitamins and Hormones"

W. M. Stanley, Rockefeller Institute—"Studies on Virus Proteins"

R. R. Williams, Bell Telephone Laboratories—"Vitamin B_1 and Cell Metabolism"

If chapters and clubs should desire lectures by the individuals who composed the former series, it is assumed that arrangements for such lectures will be made entirely independently of the office of the National Secretary.

REPORT OF COMMITTEE OF AWARD OF SIGMA XI GRANTS-IN-AID FOR 1938-39

The committee of award of Sigma Xi grants-in-aid for 1938-39 met in the Faculty Club of Harvard University July 18. Those present were: Dr. W. R. Whitney, Professor Gary N. Calkins, Professor Harlow Shapley, and Secretary Ellery. There were thirty-five applicants, covering many fields of work, and the amounts asked for varied from $50 to $567. The Executive Committee of the Society had allotted the sum of $2,000 for the grants-in-aid for 1938-39—$600 from the general funds of the Society, and $1,400 from the contributions from Sigma Xi alumni. The following awards were made:

Donald Paul Costello, University of North Carolina, $100.00. For studies on the genus polychoerus mark.

Malcolm Dole, Northwestern University, $200.00. For study of the influence of negative ions on the potentials of the glass electrode in the alkaline range, not only to discover the practical limits of the glass electrode, but also to obtain data which will lead to a better understanding of the instrument.

Frank Kelly Edmondson, Indiana University, $100.00. For an investigation of absorption of starlight by the dark nebula in Taurus by means of star counts and measures of color on plates made with 24-inch Schwarzschild reflector. Work to be carried on in collaboration with Dr. S. W. McCuskey of the Case School.

Betty Nims Erickson, Children's Fund of Michigan, $250.00. For study of hemorrhagic diseases in infants and children.

Rachel E. Hoffstadt, University of Washington, $250.00. For continuation of study of myxamatosis of rabbits, and fibroma OA and IO on developing embryo.

Ralph J. Kamenoff, City College of New York, $200.00. For selective inbreeding to study the genes which modify the expression of the flexed-tail gene; further study of the anemia of the flexed-tailed mice through an analysis of embryonic hemapoiesis.

Norton Adams Kent, Boston University, $300.00. For the development of an atomic beam of hydrogen as a source to be used in studying the fine structure of the lines in the atomic spectra of hydrogen and deuterium.

George Wallace Kidder, Brown University, $200.00. For continuation of investigation of the factors influencing growth and reproduction, using *Colpoda steini* as the experimental animal.

Harold Kirby, Jr., University of California, $200.00. For studies of protozoa of termites.

Oliver A. Leonard, Texas A. & M. College, $100.00. For study of effect of temperature and other factors on sugar transformations.

Elsie Murray, Cornell Optical Laboratory, $300.00. For standardization of technique for recording cases of aberrant color vision.

The committee also voted the following grants, to be made if further allotment of funds is possible:

Clair A. Brown, Louisiana State University, $100.00. For continuation of studies on the flora of the isolated prairies in Louisiana.

Dwight Clark Carpenter, New York State Experiment Station, $200.00 (on condition that he finds it possible to secure an additional $100.00 from some other source). For study of the effect of neutral salts on amino-acids and proteins.

George Wallace Kidder, Brown University, $100.00 additional. For continuation of investigation of the factors influencing growth and reproduction, using *Colpoda steini* as the experimental animal.

W. R. Whitney,
Gary N. Calkins,
Harlow Shapley.

(The contributions to the Sigma Xi alumni fund have exceeded the sum voted by the Executive Committee, and hence the Executive Committee is now considering the amount of further allotment to the committee of award of grants-in-aid.—Edward Ellery.)

ADDRESS BEFORE STUDENT BODY CALIFORNIA INSTITUTE OF TECHNOLOGY

Albert Einstein

My Dear Young Friends:

I am glad to see you before me, a flourishing band of young people who have chosen applied science as a profession.

I could sing a hymn of praise with the refrain of the splendid progress in applied science that we have already made, and the enormous further progress that you will bring about. We are indeed in the era and also in the native land of applied science.

But it lies far from my thought to speak in this way. Much more, I am reminded in this connection of the young man who had married a NOT very attractive wife and was asked whether or not he was happy. He answered thus: "If I wished to speak the truth, then I would have to lie."

So is it also with me. Just consider a quite uncivilized Indian, whether his experience is less rich and happy than that of the average civilized man. I hardly think so. There lies a deep meaning in the fact that the children of all civilized countries are so fond of playing "Indians."

Why does this magnificent applied science, which saves work and makes life easier, bring us so little happiness? The simple answer runs—because we have not yet learned to make a sensible use of it.

In war, it serves that we may poison and mutilate each other. In peace it has made our lives hurried and uncertain. Instead of freeing us in great measure from spiritually exhausting labor, it has made men into the slaves of machinery, who for the most part complete their monotonous long day's work with disgust, and must continually tremble for their poor rations.

You will be thinking that the old man sings an ugly song. I do it, however, with a good purpose, in order to point out a consequence.

It is not enough that you should understand about applied science in order that your work may increase man's blessings. *Concern for man himself and his fate must always form the chief interest of all technical endeavors, concern for the great unsolved problems of the organization of labor and the distribution of goods*—in order that the creations of our mind shall be a blessing and not a curse to mankind.

Never forget this in the midst of your diagrams and equations.

CHEMICAL STIMULATION IN ANIMALS

A REVIEW

William H. Cole*

Rutgers University, New Brunswick, N. J.

One of the typical and fundamental properties of living organisms is irritability, or the ability to respond to internal or environmental forces called stimuli. The preliminary events, whether physical or chemical or both, initiated by the stimulus at the locus of action, the receptor, constitute reception. The subsequent visible acts of the organism, which are known to be set off by the receptor processes, make up the response, and the part or structure concerned is called the effector. Between reception and response occur the processes or events of transmission and coordination, especially in organisms with clearly defined transmitting and coordinating structures (nerves and central nervous system).

Although it is expedient to discuss and to study these four groups of events (reception, transmission, coordination and response) separately, they should always be considered as a catenary series of processes, each one of which determines the succeeding one and is itself determined by the preceding one.

In general terms every living cell, whether alone or as part of a large multicellular individual, may be considered as an organism. In carrying on its function each cell is continuously responding to stimulation. The stimuli are disturbances in the equilibrium of the contents of the cell, or of the environment of the cell, or of both, brought about by the withdrawal or addition of energy. The resultant of all responses of a single-celled individual to the stimuli acting upon it, constitutes its "behavior." In the case of a multicellular individual the term, behavior, may apply to the complex of responses exhibited by the component cells, as a coordinated whole, or the responses of a group of coordinated cells, forming a definite part of the individual, or to single cells within the individual. Reduced to these terms all activities of living systems are elicited and continued by stimulation. Cessation of stimulation means death. The subject of stimulation then, whether called by that name or not, is the starting point for all investigations on living matter. In a large percentage of cases the stimuli are still unknown and it is necessary to study the organism from the point of view of what it does or does not do under any given set of experimental conditions. By testing many different experimental arrangements the possibilities of identifying the stimulus for a certain response are increased. Whenever the stimuli are identified, so that the response can be investigated as a function of the stimulus, the subject is often categorized and labelled as a restricted field of study. Such arbitrary classification is clearly of no real significance. It serves only as an aid in systematizing knowledge. The terms, "photoreception," "mechanical excitation" or "electrical stimulation" refer to the stimulation processes set up by the particular stimulating agent whose nature is indicated by the appropriate name.

* A part of the work reviewed herewith was supported by a grant from the Society of the Sigma Xi.

In all cases there is a locus of stimulation—some receptive structure upon which the stimulating agents exert their initial effects. These receptors vary from the compound, highly specialized and prominent structures better known as sense organs, to obscure single cells or parts of a cell, and they may be external or internal with respect to the organism as a whole. At the surface of the receptor and within it definite physical or chemical processes are either initiated, accelerated or inhibited by the action of the stimulating agent resulting in a catenary series of events, within the receptor and elsewhere, culminating in a response of some effector. The response observed may be an increased or decreased activity of the effector. In preliminary studies on stimulation the simplifying assumption is made that the magnitude of the response is some function of the intensity of stimulation of the receptor, and that the intensity of the stimulation is some function of the original energy change at the receptor surface. In animals with complete nervous systems—sensory or afferent nerves carrying nerve impulses from receptor to a central nerve organ (brain, spinal cord or ganglion), from which motor or efferent nerves carry impulses to an effector—the sequence of events is as follows: The stimulus acts through the environment upon the receptor initiating the processes of reception, the first one of which occurs at the surface of contact between receptor and environment. The last process of reception sets off the impulse in the sensory nerve leading from receptor to central nervous system, where coordinating nerve pathways carry impulses to the motor nerve connected with the effector (usually a muscle). The motor impulse initiates a series of processes within the muscle cells which finally contract or relax, constituting the response. The complete series of events is continuous. If one is omitted, the response cannot occur. In many cases it is safely assumed that the individual processes vary only in frequency, intensity or degree, as the stimulus varies in intensity, and that the response expressed quantitatively is some function of the stimulus, provided the stimulus does not exceed certain limits.

CHEMICAL STIMULATION

Since it is probable that all stimulation processes are essentially chemical in nature, it is logical to investigate so-called "chemical stimulation" in animals; *i.e.*, stimulation by known chemical substances in the environment, in the hope of revealing the general principles according to which all stimulation proceeds. If the more general principles of chemical stimulation can be formulated, it may then be possible to account for the specialized types of response, such as the senses of taste and smell.

One experimental attack upon the problem of chemical stimulation is to study stimulation by soluble compounds added to the environment of aquatic animals. In such cases the original energy change will be brought about by the alteration of the dynamic equilibrium existing in the heterogeneous system of receptors and their chemical environment. The kind and magnitude of such alteration will be correlated with the nature, properties and concentration of the substance added as well as with the nature, properties and concentration of the substances already in the environment and at the receptor surface. In studying chemical stimulation, therefore, interest centers around the relationship between the nature and properties of a substance and its ability to produce

disturbances of stimulatory proportions in the environment, and also around the nature of the energy changes which take place at the receptor surface and elsewhere in the organism.

The intensity of stimulation varies in two different ways: with the concentration of any one substance used, and with the chemical nature of the substance. To make a complete study, therefore, it is necessary to use several concentrations of each member of a series of compounds, in which the successive members differ from each other by known constants. It should be emphasized that the medium or environment of aquatic animals is always a mixture, consisting of dilute aqueous solutions of various substances and of suspended particles not in true solutions. When stimulating substances are dissolved in the water, they immediately become an integral part of the system, thereby establishing a new equilibrium. Subsequent events in the system are determined by the original composition of the medium, by the nature and concentration of the substance added and by the characteristics of the receptor mechanism. Under any set of carefully controlled conditions, the aquatic medium and the receptor mechanism are held constant, and changes in the system may be correlated with the substance added. The relative degree of change in the system as measured by the response may be called the stimulating efficiency of the substance.

For several years chemical stimulation has been studied by Cole and Allison, using a variety of animals in both fresh and sea water. A standardized technique has been used, including careful control of experimental conditions. Stimulating intensities have been kept low enough to avoid narcotic and toxic effects. Compounds tested have included the normal primary aliphatic alcohols, aldehydes and acids, mineral acids, salts of the aliphatic and mineral acids and a few non-electrolytes. A brief review of the results will be presented.

THE ALCOHOLS

Using paramecia, planaria, frogs, and barnacles (*Balanus balanoides*) it has been found that stimulating efficiency of the first five normal primary aliphatic alcohols increases about threefold as the number of carbon atoms in the molecule increases by one. This relationship is similar to Traube's rule* for narcotic effects and for surface tension. The experimental results on the barnacle, frog and planaria may be expressed by the following equation: $C_1 = C_2 a^n$, where C_1 is the concentration of a lower member of the series, C_2 is the concentration of a higher member of the series necessary to produce the same effect, a is a constant representing the ratio of successive concentrations, and n is the difference in the number of carbon atoms in the two molecules. For the barnacle, $a = 2.84$; for the planaria, 3.04; and for the frog, 2.90. Such a difference between animals should be expected, since there is no *a priori* reason why the ratio should be the same for all animals. A restatement of Traube's rule applied to stimulating efficiency of the alcohols would be as follows: concentrations of successive alcohols necessary to produce a given stimulating effect vary according to the geometrical series: $1 : a^{-1} : a^{-2} : a^{-3}$ . . . ., where a represents some real number.

* "The narcotic effect of homologous compounds (like alcohols, esters, etc.) increased with the molecular weight according to the relation $1:3:3^2:3^3$ . . . ." J. Traube, 1904, *Pflüger's Archiv. f. Physiol.*, 105, 541.

Since it is well known that alcohols and other organic compounds reduce the surface tension of water a definite amount for each compound and in accordance with the number of carbon atoms in successive members of homologous series, it is supposed that the first process in stimulation of animals by alcohols involves expenditure of surface energy. From the work of Langmuir, Harkins and others it has been established that such molecules at an oil-water interface orient in a definite way so that the non-polar group (the carbon chain) is directed away from the water, while the polar group (the —OH radical) is drawn towards the water. Since the number of carbon atoms or the length of the carbon chain increases in successive members of the alcohol series, while the —OH group remains relatively constant, the attraction between the whole molecule and the water decreases by a constant amount as each —CH_2 group is added. The tendency for the alcohols to be adsorbed at the receptor surface which is more non-polar than polar would therefore increase as the size of the molecule increases. This increased adsorption, which is a function of the field of force around the non-polar group in the molecule, would thus account for the increased efficiency of successive alcohols.

THE ALDEHYDES

The sea anemone (*Sagartia*) was used to test stimulation by the first five normal aliphatic aldehydes. Successive concentrations necessary to produce the same effect were: formaldehyde 0.061M; acetaldehyde 0.007M; proprionaldehyde 0.0023M; butyraldehyde 0.00023M; and valeraldehyde 0.00026M. The relative concentrations of acetaldehyde, propionaldehyde and valeraldehyde were 27, 9 and 1. On theoretical grounds it would be expected that formaldehyde might be an exception to the familiar 3 to 1 ratio. The failure of butyraldehyde to conform to expectations was probably due to the polymerization which had occurred, since it is well known that butyraldehyde polymerizes on standing to a greater degree than the other aldehydes. A polymerized product should be more stimulating than pure butyraldehyde.

Just as in the alcohol series, then, the increased efficiency of successive members of the aldehyde series must be correlated with the increased size of the non-polar part of the molecule, since the —CHO group is relatively constant beginning with acetaldehyde. Concentrations of aldehydes necessary to stimulate are much smaller than those of the alcohols, due to the well-known effectiveness of the —CHO group on protoplasm.

THE ALIPHATIC ACIDS

The first seven normal primary aliphatic acids have been tested on the sunfish (*Eupomotis*), the killifish (*Fundulus*) and the catfish (*Schilbeodes*) in fresh water; the barnacle and the killifish in sea water. In all cases increasing effectiveness was qualitatively correlated with increasing length of the carbon chain, but quantitative differences were marked. In the barnacle, the first three acids were about equally stimulating, but beginning with butyric and continuing through heptylic acid each one showed increasing effectiveness over its predecessor. The sunfish and the catfish were increasingly stimulated by each successive member of the series, the ratios of equally effective concentrations averaging 1.4. The killifish in fresh water, however, could be equally stimulated by suc-

cessive acids whose ratios of concentrations steadily decreased, until the last two acids were about equally effective. In sea water the killifish behaved like the sunfish in fresh water, being increasingly stimulated by each acid. These differences are undoubtedly correlated with the different environments and receptors involved, and are discussed in some detail in the original reports.

THE MINERAL ACIDS

Another important factor in stimulation by the fatty acids was found to be the hydrogen ion. It was therefore necessary to use the mineral acids, in which the anions are more nearly alike and do not show progressive effectiveness. The catfish, the sunfish, the killifish and the barnacle were again used. In all cases there was clear proof that the rate of stimulation increased as the hydrogen ion concentration ($H+$) increased and that the three acids acted alike. For the catfish the relationship was parabolic and for the other two fish, it was logarithmic. In sea water the killifish gave essentially the same results as in fresh water, indicating that the difference in environment had no effect on the efficiency of the process. The forces of primary valence are evidently responsible for stimulation by the mineral acids in these animals.

The barnacle, which was much more sensitive to acid stimulation than the fishes, gave unmistakable evidence of a slight anion effect, in addition to the predominant effect of the hydrogen ion. The order of effectiveness was $HCl > \frac{1}{2} H_2SO_4 > HNO_3$ at the same ($H+$).

With these data from the inorganic acids, it was possible to interpret more fully the results of stimulation by the fatty acids. The total disturbance by acids in the environment to which the animals respond is proportional to two factors, one related to the change in ($H+$), and the other to the field of force around the acid. Both forces may be measured in terms of the ($H+$) and a mathematical statement may be written which will describe the data very well. In that equation the variable representing the ($H+$) is multiplied by a factor whose exponent is the number of carbon atoms in the molecule. This does not take into account of course the slight effect of the inorganic anions on the barnacle.

SALTS OF THE ALIPHATIC ACIDS

To test the efficiency of the charged anion resulting from the dissociation of the aliphatic acids, the salts of the first seven acids were used on the barnacle. The solutions were brought to the same pH by adding small amounts of NaOH. Any effects of the hydrogen ion were therefore eliminated. Equal degrees of dissociation were assumed for each salt. The results showed that stimulating efficiency increased with length of the carbon chain, although the concentrations necessary to produce a given effect were considerably higher than for the acids themselves. The formate ion did or did not fall into regular order, depending upon the magnitude of the response chosen as a criterion of effectiveness.

SALTS OF THE MINERAL ACIDS

The barnacle and the killifish were used to test the effectiveness of the sodium and potassium salts of the three mineral acids, HCl, H_2SO_4 and HNO_3. The pH of the sea water was not altered by adding the salts. Two interesting results

were secured with the barnacle; first, all of the potassium salts were about five times more effective than the corresponding sodium salts; second, for both kinds of salts, at the lower concentrations, there appeared a response just reverse to that found at the higher concentrations. Closure of valves was caused by the higher concentrations and opening of valves by the lower concentrations. Two types of stimulating effect were thus revealed, analogous perhaps to the familiar exciting and depressing effects of certain drugs and narcotics. Furthermore, slight differences in anion effectiveness appeared. For the potassium salts the order of effectiveness was $Cl > \frac{1}{2} SO_4 > NO_3$; and for the sodium salts, $NO_3 > Cl > \frac{1}{2} SO_4$.

With the killifish, which is much less sensitive than the barnacle to the salts, only one effect was found, and no real difference in anion effectiveness appeared. Evidently the forces of primary valance alone are correlated with stimulation by these salts in the killifish.

NON-ELECTROLYTES

To determine the rôle of osmotic pressure in stimulation by salts some non-electrolytes were tested on the barnacle and the killifish. In general the animals responded in the same way to glycerol, urea and glucose as they did to the salts, although slightly higher concentrations were necessary to produce the same effects. However, equally effective concentrations of the non-electrolytes and of the salts were found to have quite different osmotic pressures, indicating that mere increase in osmotic pressure is not the controlling factor in all cases of stimulation by dissociated particles.

SUMMARY

From the experimental results so far obtained it may be concluded that aquatic animals are stimulated by ions and by undissociated molecules in their environment in accordance with the dynamical characteristics of the ions and molecules; *i.e.*, with all of the factors which determine the energies of motion and of orientation of the particles. Some of the properties which constitute those factors are: weight, size, mobility, chemical potential or reactivity, electrical charge and adsorbability as correlated with the chemical composition of the receptor surface and of the environment. In general the order of effectiveness of particles used in the experiments was roughly as follows: $H+ > K+ >$ $RCHO > RCOO = RCOOH = RCOH > Na+ >$ urea $=$ glucose. It may be said that the hydrogen ion is most effective because of its small ionic radius and its consequent high mobility and reactivity as a charged particle; the potassium would be less effective than the hydrogen ion because of its larger ionic radius and lower mobility, but more effective than the sodium ion because of its greater mobility in an electric field and greater reactivity with receptor components. Compounds containing long carbon chains, whether dissociated or not are relatively high in effectiveness because of their adsorbability and orientation at the receptor surface, causing changes in interfacial energy. Least effective of all are urea and glucose which act only through their kinetic or osmotic energy. To explain stimulation by all of the substances is impossible in terms of any one factor, and until more is known about the complex heterogeneous system of receptor and environment further progress in interpretation

of chemical stimulation will be difficult. Within any one series of compounds the stimulating effectiveness may be quantitatively expressed and predicted, provided the experimental material and conditions are carefully controlled.

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STUDENT, WHAT NEXT?*

A. Graeme Mitchell, M.D.
University of Cincinnati

One should always be commencing something and that without undue pride or satisfaction in what he has accomplished in the past—because from the past he should never graduate, it must only be a lesson from which to gain knowledge and gather courage to face the future.

It so happens that for a number of years I was a practitioner, and gained an insight into the difficulties as well as the joys of medical service as these arrange themselves in private practice. This was an experience which no amount of extrinsic philosophy could have replaced, and which no external contemplation could have given me an understanding of physicians' problems. For a number of years more—the addition of which to those already mentioned should entitle me at least to that respect which youth owes, but seldom gives, to middle age—I have been engaged in so-called full-time medicine and the several activities which this should imply. Ramifications of the teaching departments with which I have been connected have led me to rather broad interests and associations in the affairs of the community, especially as these relate to its health and to the various public and private agencies engaged in such work. All this is, therefore, an apology for those who have been responsible for asking me to speak to you tonight, and I hope that it will serve this purpose and make you charitably inclined towards those who must bear the onus of this invitation. At any rate, I promise that I shall demonstrate one qualification which should be demanded of every commencement speaker, namely, brevity—which is not only the soul of wit but the right of you who are so eager to commence that you have no time to wait upon one who would verbosely advise you of your future. I do not wish you finally to criticize me as Doctor Johnson might, to paraphrase him slightly, by saying, "A man who writes a Commencement address thinks himself wiser or wittier than the rest of mankind; he supposes that he can instruct or amuse them, and the publick to whom he appeals must, after all, be the judges of his pretensions."

If I had not given up the use of such an abused word, I would say that it was "intriguing" to contemplate a group such as this whose members are embarking upon another stage in their life journey and joining the ranks of those whose avowed purpose it is to help their fellow men. There are several types of service needed in the care of the sick and in the maintenance of health, and you who are now commencing must all share in a plan which needs doctors and nurses as important if not the most important units, although they do not constitute in themselves a complete plan. Those of us who happen to be physicians must realize that we are only part of the team playing in this great and worthwhile game. We must be versatile and call the signals sometimes and at others carry the ball or catch a forward pass; but it takes the cooperation of a complete team to get over the goal line, and often good kicking to increase

* Address given at the Commencement Exercises for medical students and nurses at the University of Tennessee College of Medicine, December 20, 1937.

the score. It is a well-trained and harmoniously working team which consistently rolls up the scores. There must, too, be a constant awareness of the goal and the goal of all of us must be the health of the patient. I reemphasize that it is well for those of us who are physicians to remember that doctors alone cannot solve the problems which the present and the future present to us. Medicine today needs a group such as you constitute; physicians and nurses, and more—hospitals, social workers, boards of health and other public and private community organizations must be part of the team if the goal is to be attained. We must, too, listen with respect and understanding to those to whom we are responsible, namely, our patients, who increasingly demand a voice in the plan of medical care which is at present so inadequate.

I suppose that every speaker today, whether he discusses pigs or politics, votes or victuals, crustaceans or crops, fines or finances, can find a mechanism to allow him to state that the world is rapidly changing—as though his audience were not aware of the fact, and as though the world were not constantly changing, albeit more rapidly at one time than another. All of these changes have been irresistible, and the best that could be done with them is to attempt to direct to as good purposes as possible what is new, using what has been learned from the old. It is certain, too, that the present time is one of extremes. But we always have extremes, and will until the utopian age when all of us will be both calm and intelligent. It is, after all, only the isolated and bookish philosopher who can quietly search for the middle ground and immediately adopt it. History demonstrates that most of us proceed to and by extremes and only slowly reach a middle ground, which, having attained, we remain up temporarily, and soon are off again on a rampage of extremes.

Surely, however, those of us who are concerned with medical care can with some complacency contemplate the unorthodox, because we have always had it with us in the form of one cult or another. We have knowledge that that which is fundamentally incorrect eventually succumbs, or that that which is extreme, yet contains some element of right, will soon be absorbed in proper measure for the good of Medicine as a whole. It is experience such as this which has made the physician cautious in accepting the untried and unproven, but which has made him realize, also, that out of change virtue can come if proper evaluation and adjustment can be made.

I have come to believe that the training of those who serve mankind as physicians or in allied professions leads them to a conservatism which other groups could well afford to emulate. It is not a dingy, sluggish stubbornness but rather an alert, healthy scepticism, which must, of course, not be simply a clinging to archaism. It is a belief in evolution rather than vigorous change forcibly instituted without adequate control. The physician is accustomed to regard the novel with calmness, and to welcome change only when it has been reasonably demonstrated that the new also improves. It has been encouraging to see a gradual realization that medicine must be and always has been a type of service which held the patient as the primary consideration. To this everything has been secondary and must be secondary; and there is a practical idealism in which the physician and all others concerned are but part of a plan. I am sure that that has been the basis of real medical progress, and physicians will adopt no new plan until assured that it can be consistent with the practice

that the patient comes first. More than any other group have physicians subordinated themselves to their life work and its ideals.

I am sure that those of you who are commencing are wondering what the present changes and the future changes will mean to you in your life work. In all the buffetings about today the doctor, and those allied with him in medical care, have constituted part of the great middle group which, as the expression goes, has had to "take it." He is part of the backbone which suffers from the gyrations of the head and the tail. From a practical point of view the question must be answered whether the physician can survive under our present scheme of things. I am, as a teacher, naturally interested in the future practitioner—the older of us can probably muddle through with the same old technique. But the question is whether future changes will be made which will necessitate a resetting of the practice of medicine. Personally I hope not. I would like to see continued a state which allows the physician to give of himself with a generosity which has placed him in an enviable and unique position as compared with other groups. There is something so fine and appealing in this that I dread its loss. But whatever the changes of the future I am sure that the physician and those allied with him will be able, as well as willing, to continue to give service to mankind, and such, after all, is their function.

Now I am wondering what you have in mind as your future. What are you as individuals looking forward to as your contribution to better health? Perhaps you have not yet determined and that is satisfactory because there is yet time. The final decision must be one which will lead you to a future in which you can be happy without being contented. Necessary to happiness is knowledge, and, when this is acquired, happiness cannot exist unless this knowledge is employed to good purpose. Do those of you who are physicians expect to be the busy fellows who cover the need for that almost limitless field known as general practice, or do you feel the urge to specialize? Do those of you who are nurses want to do general duty or do you wish to study further to equip yourselves to be teachers, supervisors, or specialists in some phase of nursing?

Certain facts are available to you if you consider needs. There is little in speech-making more tiresome than figures and statistics and I can bore you sufficiently without quoting too many of them. There is, however, an illuminating study made by Doctor Weiskotten* which shows that more graduates of medical schools are practicing in the larger communities than would appear to be justifiable according to population distribution. For example, although 48 percent of the population of the United States lives in communities of less than 5,000, only about 19 percent of graduates of the year 1925 are practicing in such communities. Increased speed and ease of transportation have not compensated for this entirely. It is important also to note that within six years of graduation 35 percent of the physicians from the classes of 1920 and 1925 were limiting their practice to specialties and that 70 percent of them looked forward ultimately to complete specialization. Interestingly enough, too, about 17 percent of these graduates were occupying full-time salaried positions of one type or another. There is no need to quote further in order to demonstrate that medicine today must have more general practitioners and fewer but better specialists.

* J. Assoc. Am. Med. Coll., 1932, 7:65.

The function of the medical school is to begin the training and direct the thinking of its students so that they have and will continue to have a broad outlook upon illness and health. The facts taught you are of minor importance because the facts of today may become the fictional history of tomorrow. Your teachers could but instil an ability to analyze with healthy scepticism an array of evidence and they could but interpret with and not for you. It was said by Dean Inge, "The ideal object of education is that we should learn all that it concerns us to know, in order that thereby we may become all that it concerns us to be. In other words, the aim of education is the knowledge not of facts but of values."

The medical school can hardly be responsible for complete training in all technical procedures in its undergraduate course—the hospital interneship is a necessary adjunct to the medical school. The product of all this inunction, ingestion, absorption and metabolism in your four years in medical school is the general practitioner, whom the patient must have to direct his medical life. There is something of fineness about him which has been the subject of deserved eulogy by painters, authors and playwrights. With this has also been a tendency to deplore his diminishing numbers and to believe that the good old family doctor, who treated osseous and mental fractures equally well or equally badly, is a thing of the past. The percentage is diminishing it is true, but the number of general practitioners is still great and there is no reason why, because he has greater knowledge and more facilities, the present-day graduate cannot hold to all the fine traditions of glorious service of his predecessor. The dean* of one of our American medical schools has said that these schools must be prepared to train "a large group of men whose temperaments and attitudes fit them to administer all available medical services to individuals and to families. Such graduates must have learned to know their own capacities and their own limitations; must have been sensitized to consider community preventive measures and personal and family hygiene, and equally important with diagnostic procedures and therapeutic management. It is essential that they should be competent to bring effectively and economically to patients all the usable values offered by the nurse, the public health nurse, the pharmacist, the physiotherapist, the psychotherapist, and the laboratory technician. A physician so trained, knowing his patient's needs, knowing, too, his own limitations as a physician, having integrity, sufficient to secure him against undertaking tasks beyond his competence, will know how to act as a friendly health advisor to individuals and families and to be a cooperative colleague to the health officers of the community. Without such a man, scholarly, social-minded, and of high civic integrity, no plan that can be devised for the distribution of modern medical services to the modern community can have any hope of success."

The public must perhaps be reeducated to an appreciation of the family doctor and to seek him again. Too many people today drag their noses, their tonsils, their urinary tracts, their skins, their hearts, and their adnexa to the specialist without the intervening or perhaps arresting visit to the general practitioner. It has been estimated that 750,000 lives are lost annually in this country from preventable diseases. It is largely the job of the family doctor practicing the highest type of preventive and curative medicine to stop this unnecessary loss of life.

* Quoted by Lape, Esther Everett. J. Assoc. Am. Med. Coll., 1937, 12:65.

The general practitioner of today has little excuse for not being a better physician than the one trained a generation ago. He is taught more and his instruction is better; he is given a knowledge of technical aids not formerly available; he has more facilities at his command and more hospitals to help him. In fact it is sometimes deplored that he has so much mechanical assistance that he doesn't use his senses and his analytical powers to correlate what he sees, feels and hears. If this criticism is true it need not be, and students and internes should not be allowed to overemphasize the laboratory, valuable and sometimes necessary as intelligent use of this is in diagnosis and prognosis.

What of those of you who are going to specialize, who are not discouraged by the facts which indicate greater saturation in fields other than in general practice? For the sake of the profession you represent, for your own sake, and above all for the sake of the patients who trust you, you must prepare well. There are many facetious definitions of a specialist. One of these is that he knows more and more about less and less. This definition isn't as humorous as it sounds if the specialist has a proper humility which will lead him to admit its partial truth, although this again will only drive him to increasing effort to learn more and more. Actually a specialist is one who knows more about a part or a system of the body and its disturbances than others have had the time to learn. There are a few types of practice which do not fit this precise definition, but it is not necessary to term them specialties. An example of these is pediatrics, in which the factors of physical growth and mental development bring about such modifications in all body systems and their functioning that separation in teaching and often in practice become necessary. The point is, however, that all special regions of the body are subject to those diseases and effects to which the organism as a whole is subject. Diseases and disturbed function or metabolism of one body system also affect distant organs and the entire group of body systems. It follows, therefore, that the specialist must first be a skilled physician and not primarily a mechanic, and that he must acquire the necessary background to think in general terms in regard to physical and mental health and disease. He must then attain the special knowledge gained from experience and the technical skill to exceed the average in diagnosis and treatment. All this means long and arduous apprenticeship, a great willingness to work, and a determination to excell.

The medical profession itself has recognized the dangers of over-specialization and has taken means especially directed towards limiting specialists to those whose qualifications are demonstrable. Boards of examiners have been formed in all the specialties to pass upon qualifications after an acceptable training and apprenticeship. While these are not as yet official in the sense that practice without them is prohibited, certificates from such boards are rapidly becoming recognized as necessary rather than simply desirable. The day is approaching when the certificate of the post-graduate course lasting six weeks will mean little and certainly not that its holder by virtue of it has qualified himself as a past master in some particular field of practice. Serious graduate training is necessary to qualify for specialism and no medical school can, after four years within its walls, certify that its graduates have the right to practice proficiently all manner of medicine and especially all types of surgery.

In the realm of medical specialism lie also such pursuits as those of teaching and research. If preparation for specialization in practice is difficult let it be at once admitted that the acquiring of a background for a life work in teaching

and research is arduous. It has been said that teachers and investigators are born and not made. This is only partly correct—born they certainly are but made they must be. The overwhelming desire to discover the new for oneself, the urge to pry and ponder, the enthusiasm to poke into the unknown, and absent-mindness, are not sufficient in themselves to warrant the pursuit of research; there must be the acquiring of technical perfection and the philosophic restraint of conclusion without which investigation had better not be attempted. And there must also be a willingness to accept reward from satisfaction of achievement rather than from large material remuneration. This, of course, is no real deterrent since the least satisfying attainment is purely financial success which brings with it often only satiation rather than comfortable fullness. Michael Faraday has said, "The scientist should be a man willing to listen to every suggestion, but determined to judge for himself. He should not be biased by appearances; should have no favorite hypothesis, be of no school, and his doctrines have no master. He should not be a respecter of persons, but of things. Truth should be his primary object. If to these qualities he added industry, he may indeed hope to walk within the veil of the temple of nature."

If, with open eyes, you still cannot be discouraged; if your open eyes see a goal—more desirable not simply because it is more distant—which you must drive for, then I must say "More power to you." We need special proficiency in practice, we need teachers, we need investigators—else we perish by lack of progress and a static acceptance of the present. The accumulation, the preservation, and the increase of knowledge must all three be forerunners of practice based on knowledge, and workers must be engaged in all of these activities.

But in the end it is the accomplishment that comes from effort which counts. We cannot all be the great contributors but we can add something which makes the life of our fellows happier and better, the while we pursue our own span. To be in medicine in some capacity is enough since no life work can allow greater opportunity for and satisfaction in service.

You whom I address have as assets, training, knowledge, enthusiasm, and the thrill of facing the unknown, but you have one other asset which you must realize is expendable, namely, youth. It is sometimes maintained that it is bad for youth to overestimate its importance but the actual truth of the matter is that the future must be in its flexible and dynamic hands. In such hands it will be safe provided youth will temper its acts by having some respect for those deductions which an older age can teach it because of experience.

And so I fulfill the promise that I would be brief, or at least I hope you will think that I have. I have no delusion that I have given you specific help in your future but perhaps I have conveyed to you a conviction of mine, which must be one of yours also, that your future is to be immensely worth while. If the world is a bit disturbed today, "So what?"—as the present idiom has it. I would rather be commencing in it today as a physician or as a nurse (although I am sure I could not qualify for the latter) than in any other profession or in business. Come what may there will always be a place for you if you truly serve. Perhaps you have detected, too, a bit of envy, that characteristic which we are admonished not to have but which all of us possess at times. I would like to be commencing with you if I could do that with the knowledge gained from my past mistakes. Since that is impossible I shall close with congratulation rather than with a note of envy, and I say, because you will need Him, "Go, and God be with you."

THE FEEDING OF THE CHILD*

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About 150 years ago, a familiar appearing long-necked type of nursing bottle, provided with a sponge nipple rather than one made of rubber, was being used in Italy for the purpose of feeding milk to infants, whereas a pewter kettle, resembling a modern teapot, was being employed for this purpose in England. A piece of fine cloth tied over small apertures in the tip of the spout of this kettle, served to strain the milk, and also to regulate its flow.

The obvious crudeness of these feeding devices was contemporary with relatively invisible defects in their contents, and its important influence of these invisible defects on the health and life of children I particularly desire to stress.

At the time these crude devices were in use, the universal presence of pathogenic bacteria was unknown, the scrupulous care that is required to prevent them from contaminating food was not appreciated, the rapidity with which they multiply in foods, particularly in milk, was not suspected, and furthermore, the ease with which contaminating germs of disease may be killed and rendered harmless was not understood. These priceless bits of information came at a later date, and their life-saving effect is revealed when the mortality statistics of the past are compared with those of the present. In 1770, for example, approximately 49 percent of the babies born in London died under the age of two years, and many of these deaths were the result of preventable gastrointestinal infections caused by the consumption of contaminated food, particularly milk. The miserable condition existing at that time is partially revealed by the comments found in the medical literature of the period relative to the frequency with which the tolling of church bells announced the funerals of children.

The improvement that followed the birth of the science of bacteriology and the subsequent development and application of effective sanitary measures is illustrated by more recent records, such as those from New York City, which show that between 1898 and 1931, the infant mortality for the first year of life declined more than 60 percent. A major share of the improvement in infant mortality revealed by this sample of the data recorded for this period was the result of the phenomenal decrease in fatal infections of the digestive tract.

These brief references to conditions prevalent in the comparatively recent past, and to the subsequent improvement which occurred demonstrate that the problem of feeding children is not limited merely to providing them with essential nutrients. In addition, they must be supplied with clean wholesome food which does not contain harmful living bacteria or other injurious agents.

At the present time, children and also adults enjoy the protection provided by numerous stringent sanitary measures, but instead of relying exclusively upon the diligence of food producers, food handlers, merchants and health officers, to preserve the health and life of children, careful mothers give their infants the additional protection the boiling of milk provides.

* One of a series of four public lectures sponsored by the Minnesota Chapter of Sigma Xi dealing with the general subject, "Man and His Diet."

In general, it may be said that food serves two chief purposes. First, it sustains the chemical structure of the body, and second, it supplies needed energy. Owing to the ability of the body to obtain needed calories either from fats, proteins, or carbohydrates, the sources from which energy is derived are interchangeable to a considerable degree. However, the materials required for the maintenance of the normal structure of the body are so individually indispensable that substitutions cannot be made. Consequently failure to provide essential structural materials in adequate amounts frequently results in the production of frank pathologic states or diseases, many of which can be recognized as reflecting specific dietary deficiencies.

Apparently the nutritional requirements of infants, children, and adults are qualitatively identical. In other words, the variety of indispensable structural materials needed by the human body does not vary with age. Owing, however, to the capacity exhibited by children to grow and to expend excessive amounts of energy, they require relatively more food than adults need. Consequently, definite quantitative variations in nutritional requirements characterize different age periods.

When the quantitative variations in nutritional requirements at different ages are measured in terms of energy, it is found that between infancy and puberty the average total daily caloric requirement rises from five to six hundred to three to four thousand calories, and then gradually declines to the adult level.* The energy utilized during childhood for sustaining basal metabolic processes and that used in supporting physical activity tend in general to increase with advancing age and growth in size. The expenditure of calories for the support of growth terminates, however, in the late teens.

Over-indulgence in calories leads to obesity, whereas subsistence on a grossly inadequate caloric intake leads to emaciation. These contrasting states of abnormal nutrition are quite common, thus occasion frequently arises for attempting to streamline excessively fat children and to round the undernourished ones. But since the caloric requirements of overnourished children are lower than their weights indicate, and since undernourished children need a relative abundance of calories, it is advisable to adjust the energy consumption of overfed and underfed patients on the basis of the expected normal weight for corresponding age and height rather than upon the actual weight. Lack of will power on the part of the patient explains many failures in attempts to correct obesity.

Consideration of the energy required per unit of body weight at different ages shows that during childhood the total number of calories needed daily per kilogram drops from a normal average of about 120 in early infancy to approximately 80 to six years of age. This level is maintained for eight or ten years, after which a gradual decline to the adult value of forty to forty-five calories per kilogram occurs. Obviously these changes in caloric requirement per unit of weight cannot be ignored when voluntary efforts are made to alter the child's state of nutrition. Furthermore, care must be exercised to provide an adequate supply of the essential materials, particularly where the correction of obesity is being attempted.

The amount of energy utilized for different specific purposes during childhood varies widely at different ages. In general the basal requirement per unit

* The caloric requirement for boys is higher than that for girls of corresponding age and size.

of weight rises during the first few months of life and then gradually declines to reach the adult level in the late teens, whereas the calories expended in physical activity increase until the period of puberty and then decrease. A very large expenditure of energy per unit of weight occurs particularly during infancy in supporting the extraordinary demand occasioned by the exceptionally rapid growth characteristic of this period.

The necessity, created by rapid growth and relatively high energy expenditure, of supplying infants with an exceptional abundance of nutrients, and their inability to tolerate and digest many of the foods commonly included in the diet of more mature individuals, are factors which combine to make the first few months one of the critical periods of life. The food provided by nature to supply the special requirements of this critical period is milk, and when human milk from healthy mothers is available in liberal amounts babies thrive on it. This is interpreted as acceptable evidence of its adequacy.

Chemical analysis of human milk shows that it contains sugar, fats, proteins, a long list of salts, an assortment of vitamins, a large amount of water, and various other identified and unidentified substances. Furthermore, its fats include a variety of fatty acids, two of which probably are essential for normal nutrition, and its proteins contain the ten amino-acids known to be essential for maintenance and growth and for the construction of tissues. The secret of the adequacy of breast milk as the sole food for the first few months or critical period of life doubtlessly lies, therefore, in the wide variety of substances which enter into its composition. Its composition also indicates what the mother's diet must include if depletion of her body is to be avoided during lactation.

The most commonly used substitute for human milk is cow's milk. Although these two foods contain comparable varieties of organic and inorganic substances and look somewhat alike, nevertheless, they are by no means identical foods. With respect to the partition of their solids human milk is relatively richer than cow's milk in substances utilized mainly as sources of energy, but is poorer than cow's milk in materials which enter into the construction of tissues. Whether these observed differences represent natural adaptations which correspond with differences in the respective nutritional requirements of children and calves is a question which invites speculation, but instead of indulging in speculations on this point I prefer merely to call attention to the observation that the death rate for breast-fed babies is distinctly lower than that recorded for artificially fed infants.

A more detailed comparison of these two foods shows that human milk is unique in its relatively high sugar content. Its total protein, however, is distinctly lower than that of cow's milk. This difference applies to casein rather than to lactalbumin, for the latter is more abundant in human than in cow's milk. Also with regard to their respective content of inorganic substances these foods are dissimilar. In general cow's milk is relatively richer in these materials.

Since cow's milk and human milk are not chemically identical, the success that commonly attends the feeding of cow's milk to young infants reveals the possession by babies of a capacity to tolerate and to utilize a mixture whose composition departs far from that of their natural food, human milk. The limit of the young infant's ability to tolerate and to assimilate this alien food usually is not exceeded if water and sugar are added to cow's milk and the resultant mixture is boiled. This last procedure enhances the digestibility of the formula

and also sterilizes it. The desirability of sterilizing cow's milk becomes obvious when we consider that this food is collected in barns.

Regardless of whether the baby is nursed or bottle fed, it is common practice to start the administration of orange juice and cod-liver oil in the first or second month of life. Although each of these foods contains a variety of substances they are added to the diet mainly for the purpose of augmenting the consumption of vitamins A, C and D. The addition of orange juice to the diet is particularly indicated in instances where artificial feeding is necessary, owing to the fact that the aging and boiling of cow's milk are factors which tend to reduce its vitamin C content. The value of cod-liver oil as an important source of iodin probably is not generally appreciated.

During the transition from a milk diet to one of more varied character, cereals, vegetables, fruits, eggs, and meats are gradually added with the result that when the baby reaches its first birthday its diet includes a liberal variety of foodstuffs. Throughout the remaining years of life all of the essentials of nutrition probably can be obtained by daily subsistence chiefly on the specified foods shown in the following list:

1. One and one-half pints of milk.
2. One to two eggs.
3. Meat, fish, fowl, kidney, liver.
4. Two or more vegetables.
5. Orange or its equivalent.
6. Cooked fruit.
7. Cod-liver oil.

The remainder of the diet may be selected according to taste, but these additions should not consistently replace the specified foods. The unspecified selections made according to taste will ordinarily include breads, cereals, potatoes, and desserts. Since I am discussing the feeding of children I suspect I should also mention peanut butter sandwiches, hamburgers, hot dogs, popsicles, ice cream cones, and candy in the optional list.

Refusal on the part of the child to eat a liberal variety of foods creates a very distressing problem whose correction is difficult to accomplish. Relative to the solution of the difficulty, I venture the suggestion that children living in homes where care is exercised to provide an abundance of the foods included in the specified list, will tend in general to become more accustomed to eating a varied diet than other children who live in homes which provide a relative abundance of the optional foods. Consequently, parents may avoid converting the family table into a daily battle ground by placing proper orders with the grocer and butcher.

Concealed in the commonplace foods included particularly in the specified list are numerous individually indispensable nutritional factors. Scientific investigations have resulted in the identification and isolation of several of these essentials and to some of the investigators who accomplished these discoveries the Nobel prize has been awarded. But in spite of the splendid studies that have been made, many unidentified essentials of nutrition doubtlessly remain hidden in the foods we consume and await future discovery.

The most abundant single substance present in the diet outlined in this paper is water. The importance of this well-known ingredient of the diet becomes

apparent when we consider that life does not exist in the absence of water. The water we carelessly drink and consume with food automatically distributes itself into separate compartments of the body. About 70 percent of the retained water is confined within the cells of the tissues and the remaining 30 percent is extracellular in position. Of the latter, approximately four-fifths occupies the interstitial spaces between the cells, and the remaining one-fifth circulates in the vascular system.

Deprivation of water leads first to a depletion of the interstitial fluid, and when this relatively elastic reserve supply approaches exhaustion, the volume of the blood plasma falls and its viscosity increases. Continuance of the process of dehydration occasions the loss of excessive amounts of intracellular fluid.

Severe loss of body water combined with general starvation produce an extremely emaciated body clothed in an apparent excess of loose wrinkled skin which is thrown into coarse inelastic folds. In the absence of serious complications, a rather prompt recuperation usually follows the liberal administration of suitable fluids and nourishment.

During dehydration important salts escape from the body, and under certain circumstances this process of demineralization may be complicated by a derangement of the normal acid-base equilibrium of severely depleted body fluids owing to a loss of a significant excess either of base or of acid ions. The seriousness of alterations in the electrolyte balance of the fluid matrix of the body is dependent upon the fact that changes of this character seriously derange the numerous interrelated chemical reactions which collectively comprise metabolism. Recognition and correction of grave complications of this character require examination of the eletrolyte structure particularly of the dehydrated patient's blood plasma, the fluid portion of the blood.

With respect to its electrolyte structure, normal blood plasma is a dilute solution of almost equally balanced base and acid ions. Its electrolyte structure resembles that of sea water, and is also remarkably similar to that of the interstitial fluid. Common table salt, or sodium chlorid, is the chief inorganic salt present in each of these three fluids. In a sense, therefore, a small sample of modified sea water, trapped in the body, bathes the cells of the tissues. Like other body fluids, the blood plasma contains a weakly alkaline buffer substance, the bicarbonate of the blood, which by increasing or decreasing serves to prevent variations in the ratio of strongly basic ions to strongly acid ions from producing incompatible alterations in the normal slight alkalinity of this fluid.

During the course of severe and protracted vomiting, the body loses a relatively large amount of hydrochloric acid. This removal of an excess of strong acid ions is associated with a compensatory increase in the bicarbonate of the blood plasma. The clinical condition associated with a change of this character is known as alkalosis.

If, however, the depletion of body fluids is the result of profuse diarrhea a large amount of fixed base, which predominates over acid in the intestinal discharges, is lost. The effect of this excretion of a significant excess of fixed base on the bicarbonate of the blood plasma is just the opposite of that produced by a depletion of chlorid or strong acid ions. Under these circumstances the bicarbonate decreases. This type of change in the electrolyte structure of the blood plasma is spoken of clinically as the condition of acidosis.

The gravity of a derangement of the electrolyte balance of the fluid matrix of emaciated and dehydrated patients is illustrated by the alarming symptoms they manifest. Under these circumstances the dry inelastic skin becomes ashy grey in color, the concentrated blood makes the lips appear fiery red, the pulse becomes weak and thready, breathing is shallow and irregular or deep and pauseless, the kidneys cease to function, stupor deepens into coma, convulsions may intervene, and the lusterless, glazed eyes sink into their sockets.

This picture illustrates the necessity of supplying the body with adequate amounts of water and of various salts, particularly ordinary table salt. The nutritional importance of these commonplace substances doubtlessly is on a par with that of vitamins or other indispensable nutrients.

A significant derangement of the normal acid-base equilibrium of the fluid matrix of the body is far too serious a condition to permit self-medication with proprietary preparations whose capacity to correct an acid or an alkaline state, or to rid the body of acids or alkalies is highly praised and widely advertised. The preparations used by physicians to correct alkalosis or acidosis include Ringer-Tyrode's solution, physiological salt solution, Hartman's solution and glucose solution. Instead of discussing the special indications for preference in the use of each of these repair solutions, I prefer merely to call attention to the fact that not one of these therapeutic agents is advertised to the public.

The consumption by children of diets deficient in available calcium, or their failure for various reasons to retain a normal amount of this mineral, leads to a gradual decline in the quantity of this substance in the blood. A slightly subnormal blood calcium level is associated with symptoms such as nervousness, irritability, and restlessness during sleep. A more marked decline in the blood calcium produces the clinical condition known as tetany, which in florid cases is characterized by protracted spasmodic contractions of the hands and feet as well as by severe generalized convulsions. The specific relationship between calcium deficiency and tetany is dramatically revealed by the prompt curative effect particularly of calcium chlorid. Through the interaction of the calcium contained in different foods, particularly milk and the vitamin D obtained either through the effect of sunlight on the skin or by the consumption of cod-liver oil, the occurrence of the convulsive state known as tetany usually is prevented.

In young infants the hemoglobin normally is relatively high but during infancy it tends to fall. Protracted subsistence on a diet deficient in iron augments this tendency, and frequently results in the development of varying degrees of nutritional anemia. The administration of iron serves to correct this condition, but a more favorable response usually is obtained when copper is given in addition to iron. The inclusion in the diet of meats, particularly liver and kidney, as well as eggs, sea foods and various vegetables and fruits probably can be relied upon to provide the iron and copper required for the synthesis of a normal amount of hemoglobin.

The importance of including iodin in the diet is revealed by the special effect of this mineral on the thyroid gland. A dietary deficiency of this mineral is prone to cause the development of a special benign type of goiter. This type of goiter is so prevalent in some regions, such as that bordering upon the great lakes, it becomes a public health problem. Various schemes have been

devised to solve this problem, important among which is the policy of adding a small amount of iodin to common table salt. The adoption of a method of this character for guaranteeing sufficient dietary iodin to prevent goiter seems necessary owing to the fact that the iodin content of vegetables and fruits varies greatly depending on where they are grown.

In addition to supplying the amino-acids needed for the construction of tissues, the protein of the diet also serves to maintain the plasma protein at a necessary level.

The rôle the small amount of protein present in plasma plays, through the colloidal osmotic it exerts, in contributing to the maintenance of normal volumetric relationships between the intravascular and interstitial fluids is revealed when the plasma protein is considerably reduced.

Protracted subsistence on a diet extremely low in protein reduces the plasma protein. The accompanying fall in colloidal osmotic pressure permits fluid to escape from the vascular system and collect in the interstitial spaces. In this manner edema or dropsy of nutritional origin may develop. A similar water-logging of the tissues occurs when the blood proteins are depleted as a result of the excretion, in nephritis or nephrosis, of urine containing a large amount of albumin.

In association with diets deficient in proteins of animal origin, and in vegetables, a peculiar disease may develop which is known by the name pellagra, given to it by Italian peasants many years ago.

The strikingly characteristic manifestation of this disease is the appearance of symmetrically distributed skin eruptions involving exposed areas particularly. Exposure to sunlight is prone to initiate the development of these lesions, and advantage may be taken of this fact when the diagnosis of the disease is in question. At first the lesions resemble sun burns, but later they assume a brownish discoloration Subsequently the involved areas desquamate and leave a smooth velvety appearing surface.

The manifestations of pellagra are by no means limited to changes in the skin, for in addition pellagrous patients may also exhibit symptoms which reveal involvement of the digestive tract and of the nervous system.

For a long time, pellagra was attributed to eating spoiled corn and consequently it was frequently spoken of as maize disease. The possibility, however, of determining the exact etiology of pellagra followed the observation that diets similar to those associated with the development of human pellagra produce the condition known as black tongue in dogs. Analysis and comparisons of these diets with those which prevent pellagra and black tongue, recently resulted in the discovery that nicotinic acid is an effective agent in preventing and curing black tongue in dogs and pellagra in man. This observation provides significant evidence that nicotinic acid is the vitamin concerned in pellagra. Apparently this substance is a part of the naturally occurring vitamin B_2 complex. Good sources of the pellagra-preventing factor include lean beef, liver, fish, eggs and yeast.

A deficiency of vitamin D, due either to a dietary inadequacy, or to a failure of ultraviolet rays of the sun to activate ergosterol of the skin results in the development of rickets.

The conspicuous deformities of the extremities, caused by this disease, are well known and probably need not be dwelt upon. Previous to the appearance of gross deformities of this character, X-ray examination of the bones may

reveal the presence of rachitic changes such as rarefaction or poor calcification of bones as well as a slightly concave irregularity and enlargement of the end of the shaft of bones.

Microscopic examination of these bones reveals interesting and complicated changes. Normally the cartilage cells capping the extremity of a growing bone are arranged in regular columns parallel to the long axis of the bone, and a uniform horizontal zone of calcified matrix marks the juncture of the cartilage with the subjacent newly formed bone. Furthermore, the fine capillaries beneath this calcified zone have an orderly arrangement similar to that of the cartilage cells toward which they are budding.

In rickets the uniform transverse zone of calcified matrix disappears, the cartilage cells lose their orderly arrangement and assume the form of irregular finger-like projections. Furthermore, the capillaries budding toward the cartilage cells lose their orderly arrangement.

Following exposure of the skin to ultra-violet rays or the administration of cod-liver oil or suitable substitutes, the transverse zone of calcified matrix reäppears and the remaining details of the histologic structure of the bone are gradually restored to normal.

Rickets is the result as a disturbance of the intermediate metabolism of phosphorous and calcium occasioned by a deficiency of vitamin D. The natural distribution of this vitamin is so restricted it is found in very few foods in quantities sufficient to be of special therapeutic value. The advisability, therefore, of exercising the precaution, particularly during the winter months, of providing children with a special supply of vitamin D in the form of cod-liver oil or appropriate concentrates is apparent.

Our present knowledge of vitamins dates from 1911 when Funk discovered a peculiar disease, common in the orient and known as beriberi, to be the result of a dietary deficiency of a previously unknown substance. In connection with this discovery, he coied a new word, vitamin, which like a historic shot, was soon heard around the world.

Beriberi is characterized in adults by the development of paralysis. During infancy and childhood, however, it is prone to feature a marked enlargement of the heart, and fatal cases usually are the result of cardiac failure. The cardiac enlargement seen in beriberi and the return of the heart to normal size following the administration of the antineuritic vitamin B are easily demonstrated by serial X-ray examinations. The antineuritic vitamin B is quite widely distributed in natural foods, thus subsistence on a varied diet effectively prevents the occurrence of beriberi.

Subsistence on a diet deficient in vitamin A or its precursor, a group of yellowish vegetable pigments, the carotenes, leads to the development of a peculiar thickening of the cells lining various moist parts and organs of the body. A severe depletion of vitamin A produces the clinical condition known as xerophthalmia. This disease is characterized by the appearance of thickenings of the epithelium covering the cornea or transparent part of the eye. These corneal lesions are prone to become infected with the result that opaque scars are produced which cause permanent blindness. Xerophthalmia is quite rare in America, but recent studies have revealed an unsuspected high prevalence of slight vitamin A deficiency. The discovery of slight degrees of vitamin A deficiency requires special tests of vision.

Under the influence of light the visual purple of the cones of the retina of the eye normally bleaches and when it becomes colorless it has been converted into vitamin A. This vitamin regenerates visual purple but the restoration is not 100 percent. Consequently in the absence of a reserve supply of vitamin A, a subnormal amount of visual purple is produced. Under these circumstances a definitely delayed ability to see distinctly in dim light results. This condition is known as night blindness.

The prevention of night blindness, and of the numerous other pathologic changes which culminate in severe instances in xerophthalmia is contingent upon the inclusion of an adequate amount of vitamin A, or its precursor, carotene, particularly beta-carotene, in the diet. This vitamin and its precursor are widely distributed in nature, particularly in fish-liver oil, milk, butter, eggs, certain fruits and vegetables.

A deficiency of vitamin C decreases the strength of the cement substance which normally unites the cells covering the moist surfaces of the body. Changes of this character may weaken the inner lining of blood vessels to the extent that severe hemorrhages occur, and it is the manifestations of hemorrhage which facilitate the diagnosis of examples of frank scurvy. Severe cases of scurvy are quite rare in America. Latent forms of the disease are very difficult to recognize, thus no accurate estimate of the prevalence of slight vitamin C deficiency can be made. Good natural sources of this vitamin include nearly all fresh fruits and vegetables.

During recent years, increasing use has been made of special diets as an adjunct to the treatment of diseases. The manner in which the diet may be advantageously modified to meet special indication probably can be illustrated by briefly discussing the dietetic treatment of eczema, epilepsy and coeliac disease.

For a long time a causal relationship between fats and eczema has been suspected, and this suspicion led to the practice of feeding low fat diets of eczematous patients. Splendid fundamental studies, conducted by Dr. Arild Hansen in the department of pediatrics at the University of Minnesota, resulted in the observation that the unsaturated fatty acids of the blood were subnormal in some types of infantile eczema. Restoration of these fatty acids to normal levels, accomplished by feeding oils rich in unsaturated fatty acids, was also shown to be accompanied by a gradual return of the skin to normal. These studies have revealed a previously unsuspected rôle the unsaturated fatty acids in the diet play in preserving the normal condition of the skin.

In the past the treatment of epilepsy was almost exclusively confined to the administration of sedative drugs and to the provision of favorable environmental conditions, but recently the dietary therapy of the disease has assumed a position of major importance. Various studies, particularly those of Dr. Irvine McQuarrie, chief of the department of pediatrics at the University of Minnesota, have made water restriction diets, acid ash diets, and ketogenic diets the foundation of the treatment of epilepsy.

A very peculiar type of diet is necessarily resorted to in the treatment of children who are unable to digest and tolerate fats and starches. In this condition, which is known as coeliac disease, or chronic intestinal indigestion, the restricted variety of foods the patient can tolerate usually includes buttermilk, cottage cheese, banana, egg white, and cod-liver oil. This protracted nutritional disorder reduces the body to the miserable state.

In this brief discussion of the feeding of the child, it has been possible merely to outline some of the disastrous effects of subsistence on diets deficient in different essentials of nutrition. If we now contrast the picture of robust health a complete diet can produce with the convulsive state of calcium deficiency, with the miserable acidotic starved condition that deprivation of water and salt produces, with the deformed extremities, the heart disease, the hideous skin eruption and the hemorrhages and blindness vitamin deficiencies cause, there seems to be no escape from the conclusion that the preservation of health and life are largely contingent upon electing to eat a liberal variety of wholesome foods.

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Index cards for newly elected members and associates are available *gratis* upon requisition from chapter secretaries to the National Secretary. These cards should be made out in duplicate, one set being retained for chapter files and one set being sent to the National Secretary for filing in the permanent records of the national organization.

NATIONAL CONSTITUTION

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Chapter secretaries are asked to send to the National Secretary in October of each year changes in their enrollment lists as follows: 1. Names and addresses to be deleted from the previous list; 2. Names and addresses to be added to previous list; 3. Changes of addresses of those on previous list who may have moved to a new address since the list was submitted.

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EDWARD ELLERY,
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